
6. DESIGN CRITERIA

6.1 STRUCTURAL ANALYSIS

A three-dimensional structural analysis software (ETABS) was used to create a computer model of the **Annex Building (Maysan National Highschool Annex)**. The geometric model was created using the results of ocular inspection and field measurement results that was used to develop a Computer-Aided Design (CAD) drawing.

Detailed field investigation such as chipping-of-concrete works, crack mapping, concrete coring tests, excavation of foundation, rebar extraction and testing and rebound hammer test results were also done as input into the Design Criteria for structural analysis. This design criteria contains all relevant information and assumptions, e.g., loads, concrete strength, strength of steel reinforcements, etc., that will be discussed later in the succeeding section. Note that the compressive strength of concrete used in the structural analysis was derived based on the correlation of the concrete strength from the rebound hammer and the coring tests.

Subsequently, static and dynamic analyses of the school building were conducted using code-based load combinations imposed on the structure. The structural analysis uses the strength design method that conforms to the National Structural Code of the Philippines (NSCP, 2015), 7th Edition.

6.1.1 BASIS FOR ANALYSIS RESULTS

The available plans and specifications, design criteria, and data from the field investigations were used as basis in the structural analysis of the said school building. The field tests conducted on representative structural elements are compared with the rest of the structure to determine which of the structural elements are typical to the representative elements.

6.1.2 STRUCTURAL ANALYSIS CRITERIA

This section provides criteria used in present review/analysis of the existing **Annex Building (Maysan National Highschool Annex)**, which was derived from the data gathering and field investigation. This analysis was performed using the concrete strength based on the results of correlation of rebound hammer test and concrete coring test.

6.1.2.1 DESIGN CODES

The analysis and design of the structural system of the building will be in accordance with the laws and regulations governing in the Philippines. The following codes and standards have been identified as applicable, in whole or in part, to the structural analysis and design of the **Annex Building (Maysan National Highschool Annex)**:

- A. National Structural Code of the Philippines 2015, 7th Edition (NSCP 2015)
- B. Association of Civil Engineers of the Philippines (ASEP) Steel Handbook 2004
- C. American Institute for Steel Construction, 8th Edition (AISC)
- D. American Concrete Institute, 318-08 (ACI)
- E. American Society of Civil Engineers, 7-98 (ASCE)

6.1.2.2 MATERIAL STRENGTH

- A Concrete compressive strength (f'_c)
. (Based on the correlation of the core test results and rebound hammer test results)

Columns, Beams, Slabs, Shearwalls	24.24 MPa (3,515 psi)
Foundation	22.61 MPa (3,279 psi)

- B Steel reinforcing bars for concrete will be deformed bars of billet steel
. (Based on the strength of steel prevalent during the time of its design conception)

Yield strength (f_y)	425 MPa (61,641 psi)
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6.1.2.3 DESIGN LOADS AND FORCES

Design loads for the structure and foundation are based on the NSCP 2015 requirements.

6.1.2.3.1 DEAD LOADS

Dead loads on the structure include the weight of all items that are attached to the structure and are likely to remain in the as-built location throughout the life of the structure. Beams, columns, floor slabs, exterior walls, roofs, non-structural finishes and utilities.

- A. Superimposed Loads

Roof Loads

Trusses	0.60 kPa (13 psf)
Purlins and Miscellaneous	0.15 kPa (3 psf)
Roofing Material	0.04 kPa (0.8 psf)
Insulation	0.04 kPa (0.8 psf)
Ceiling	0.24 kPa (5 psf)
Electrical Fixtures	0.10 kPa (2 psf)

Floor Load

25 mm Floor Finish	0.77 kPa (16 psf)
Partition	0.96 kPa (20 psf)
Electrical and Mechanical Fixtures	0.20 kPa (4.1 psf)
Ceiling System	0.20 kPa (4.2 psf)

Wall (4" Medium Density CHB both face plastered)	3.17 kPa (66 psf)
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Stair	3.52 kPa (74 psf)
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- B. Unit Weight of Materials

Structural Steel	77.0 kN/m ³ (490 pcf)
Reinforced Concrete	23.6 kN/m ³ (150 pcf)

6.1.2.3.2 LIVE LOADS

Live loads include anything that can possibly be moved in or out of the structure over the course of its life. This includes people, furniture, equipment, and other similar items. Predicting the live load that structures will see is highly dependent on the use or that the structure will be put to.

The type of use is normally referred to as the “occupancy” of the structure. Different parts of the structure are assigned different occupancy live loads depending on their use.

• Classrooms	1.90 kPa (40 psf)
• Corridors	3.80 kPa (80 psf)
• Stairs	4.80 kPa (100 psf)
• Roof	0.60 kPa (13 psf)

6.1.2.3.3 LATERAL LOADS

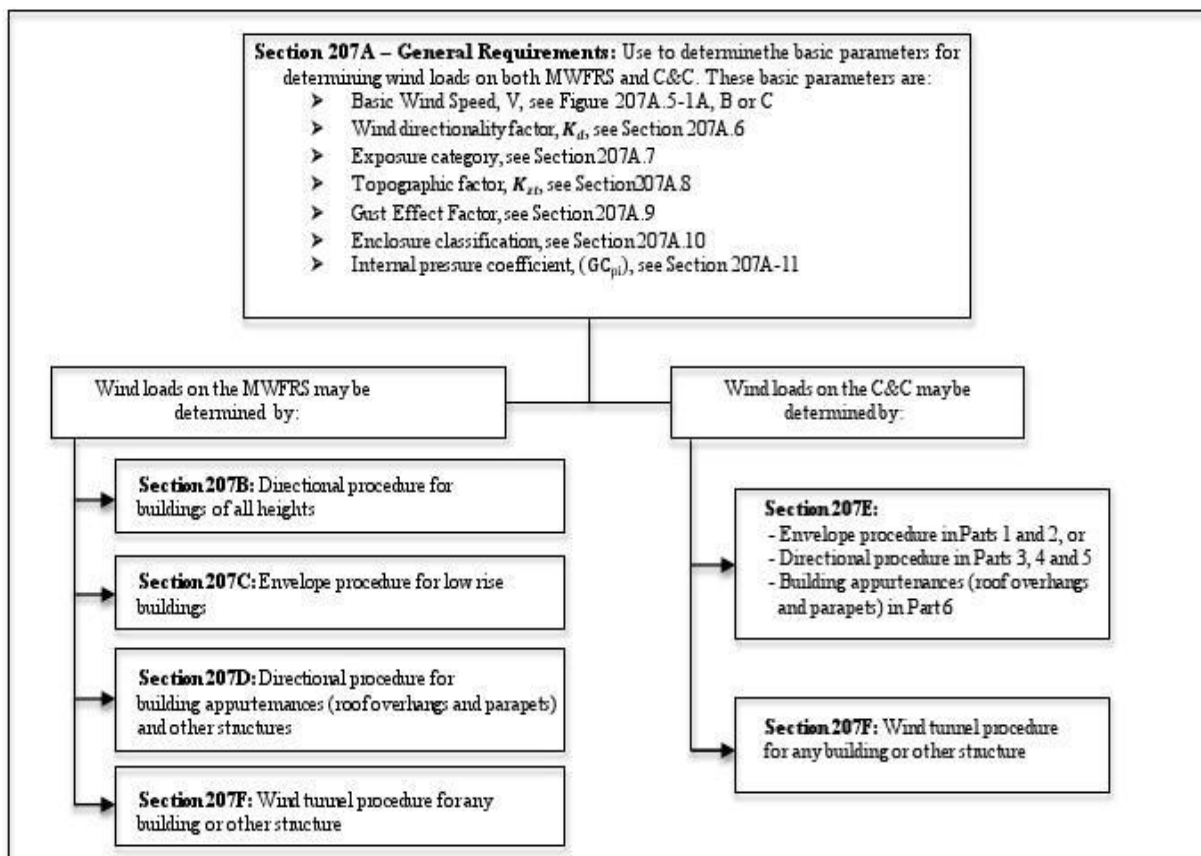
A. Earthquake Loads (Based on parameters specified in the NSCP 2015)

Earthquake forces are generated by very dynamic events. For certain types of structures a static equivalent method may be used to estimate the forces applied to the structure.

Design Base Shear	$V = \frac{C_v I}{R T} W$
Seismic Source Type	A
Seismic Zone	$Z =$
Importance Factor	$I = 1.50$
Soil Type	S_D
Numerical Coefficient (Special Reinforced Concrete Moment Frame)	$R = 8.5$
Closest Distance to known Seismic Source (Approximate distance to the West Valley Fault)	12.8 km
Near Source Factor	$N_a =$
Near source Factor	$N_v =$
Seismic Coefficient, C_a	$0.40 N_a$
Seismic Coefficient, C_v	$0.56 N_v$
Structural Period	$T = C_t (h_n)^{3/4}$
For All buildings	$C_t = 0.03$

B. Wind Loads (Based on parameters specified in the NSCP 2015)

The NSCP 7th edition specifies the procedures for generating the design winds loads for buildings and other structures. An outline of the overall process for the determination of wind loads as shown in the figure below.



6.1.2.3.4 LOAD COMBINATION

Peak (maximum) loads occurring at the same time have less probability and as such are not combined in this manner. The NSCP however specifies different load combinations considering overload factors to capture extreme conditions especially for environmental loads. On the other hand, the resistances are reduced to capture material and other uncertainties that affect mechanical strength. However, the design ensures that even with overload conditions and reduced strength, the structure can still resist the loads during its service life. The reinforced concrete superstructures shall resist the most critical effect of the listed Ultimate Strength design combinations listed below and the analysis of the stresses developed in the structural member shall resist the most critical effect of the Allowable Strength design/service load design combinations below.

A. Ultimate Strength Design

- $1.4(D+F)$
- $1.2(D+F+T) + 1.6(L+H) + 0.5(L_r \text{ or } R)$
- $1.2D + 1.6(L_r \text{ or } R) + (f_1L \text{ or } 0.80W)$
- $1.2D + 1.6W + f_1L + 0.5(L_r \text{ or } R)$
- $1.2D + 1.0E + f_1L$
- $0.9D + 1.6W + 1.6H$
- $0.9D + 1.0E + 1.6H$

Where:

D = Dead Load
L =Live Load
E =Earthquake Load (One way and Orthogonal Direction)
Lr =Roof Live Load
F = Loads due to weight and pressure of fluids
W = Wind Load

6.2 COMPUTER MODEL

The “Extended Three Dimensional Analysis of Building Systems” (ETABS) software was used to create a mathematical model of the **Annex Building (Maysan National Highschool Annex)**. The software allows a realistic modeling and distribution of loads for simple to complex 3-D structures.

The measurements and dimensions used in the model were based on the on-site measurements from the field works. The structural parameters defining the model were taken from the results of the detailed field investigation. The figure below shows the rendered 3-D model of the **Annex Building (Maysan National Highschool Annex)**.

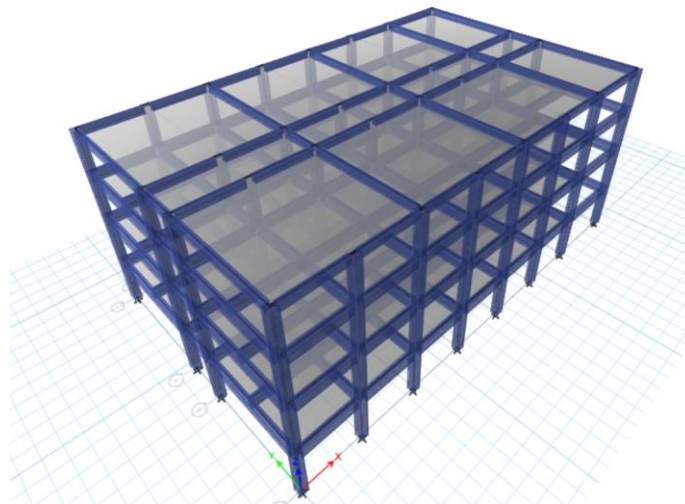


Figure 1 – Annex Building – Maysan National High School Annex